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13. ABSTRACT (Maximum 200 words)

The research involved studies of the assimilation of polyaromatic hydrocarbons and polychlorinated biphenyl congeners by an amphipod and a chironomid. Assimilation efficiencies were calculated for these species using radioactively labeled benzoapyrene and hexachlorobiphenyl which was allowed to adsorb to sediment particles of various sizes. One conclusion of the research was that differential bioavailability of a chemical may not depend as much on the behavior of the organism as on the nature of the compound and its interaction with the sediment components.

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PROJECT SUMMARY:
ASSIMILATION OF SELECTED PAH AND PCB CONGENERS SORBED TO SEDIMENT BY BENTHIC INVERTEBRATES

Michael J. Lydy

Work performed at:
Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
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Grant administered through:
Cooperative Institute for Limnology and Ecosystems Research
2200 Bonisteel Blvd.
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28 August 1992

Interim Report for the period 30 November 1991 - 30 December 1992

Prepared for

Society of Environmental Toxicology and Chemistry (SETAC)
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This project summary is a report on the work completed to date on the assimilation of PAH and PCB congeners by the amphipod *Diporeia* spp. Funding for this project was originally awarded by SETAC to Dr. Michael Lydy, and supported Ms. Gail Harkey under the direction of Dr. Michael Lydy and Dr. Peter Landrum after Dr. Lydy assumed employment with the U. S. Geological Survey. An interim report for the period 1 Dec. 1990 - 30 Nov. 1991 was completed and submitted to SETAC and the grant originator, the U. S. Air Force last year, and summarized the objectives and work completed at that time. Objectives for the second year of funding were stated in that report. After re-evaluation of the data and work completed through December of 1991, the objectives for the second year of funding were altered as follows:

(1) Develop a technique to easily estimate assimilation efficiency in *Diporeia* spp. via organism exposure to dosed sediment with subsequent determination of chemical content in fecal material.

(2) Compare assimilation efficiencies simultaneously for a PAH and PCB , using dual-labeled radiotracers.

(3) Compare assimilation efficiencies as stated above for organisms exposed to selected particle-size fractions of dosed sediment.

(4) Prepare manuscripts and presentations on data obtained for submission to the Environmental Toxicology and Chemistry journal and the annual SETAC meeting.

To better estimate assimilation efficiencies for a selective feeding benthic organism such as *Diporeia* spp., it was necessary to use the direct approach by determining the relative concentrations of a radiolabeled contaminant in sediment and fecal material. In the first assay, individual *Diporeia* spp. were exposed to ^{14}C-benzo(*a*)pyrene (BaP) dosed sediment for intervals of 1, 3, 5, and 7 days. At the end of each timed interval, the concentrations of BaP in sediment, whole organisms, and fecal pellets were determined. The numbers of fecal pellets produced by individual animals were counted to select between feeding and nonfeeding organisms. This enabled the amount of compound accumulated from food to be estimated and separated from the amount accumulated from water. Feeding rate can be calculated by the following equation:

$$FR = \frac{\text{dry weight fecal pellets (mg)}}{\text{exposure interval (h) x wet weight of animal (mg)}}$$

From this, an assimilation efficiency can be calculated for each timed interval as:

$$AE = \frac{Ca}{FR \times SI \times t \times Cs,}$$

where AE = assimilation efficiency (%)

Ca = mean concentration of chemical in the animal, taken as the mean concentration difference between feeders and nonfeeders (dpm/mg)

SI = selectivity index, estimated as 6

t = exposure interval (h)

Cs = concentration of chemical in sediment (dpm/mg dry weight)

Calculated assimilation efficiencies for the first assay ranged from 14.5 to 23.9%, using BaP-dosed sediment. Concentrations of BaP increased in both feeding and nonfeeding organisms. Even though contaminant concentrations increased in organisms over time, concentrations in fecal pellets were highest on day 1 and gradually dropped over the course of the 7 day study.

A second assay was conducted in the same manner as the first, with the addition of a second radiolabeled compound, ^{14}C hexachlorobiphenyl (HCBP). *Diporeia* were placed in twice the amount of sediment as that used in the first assay, as the drop in fecal pellet concentration may have occurred with depletion of organic-rich food contained in the sediment exposures. Exposed organisms were examined at 3, 7, 10, and 14 day intervals. Calculated assimilation efficiencies for BaP ranged from 9.3-19.1% (at 7 and 10 days, respectively), while efficiencies for HCBP were generally greater than 100%. Accumulation of both compounds in fecal pellets dropped after 7-10 day exposure periods. Although a larger amount of sediment was available to individual organisms in this assay, the decrease in fecal pellet concentration may have been due to depletion of a specifically ingested particle size fraction of sediment particles.

Particle size distributions of the BaP, HCBP, organic carbon, and particle mass were examined. Concentrations of BaP and organic carbon were highest

in the >5μm particle size fraction. The fraction with the greatest mass was the 20 - 30 μm size class, and this was the class that contained the greatest concentration of HCBP. Thus, the role of particle size and compound distribution was thought to provide insight into the differential bioavailability. Therefore, to further investigate this phenomena, a third assay was completed. Sediment pre-sieved to ≤ 20μm was dosed with the two compounds and was run as in the previous assays, with 3, 7, 10, and 14 day exposure periods. Fecal pellet concentrations stayed relatively constant from day 7 to day 14 for HCBP, but again dropped for BaP after day 10. Calculated assimilation efficiencies for this data set ranged from 1.2 to 2.9% for BaP and were close to zero for HCBP. Differential accumulation between feeding and nonfeeding organisms disappeared when the organisms were exposed to these materials. Accumulation of HCBP in feeding animals was lowered by a factor of two in the third assay compared with data from the previous assay. Differential partitioning of HCBP to the various particle sizes in sediment may explain the differences in assimilation efficiency and accumulation between the two assays.

The uptake and bioaccumulation of hydrophobic organics for a relatively nonselective feeder, *Chironomus riparius*, also exhibited significantly enhanced accumulation of the chlorinated hydrocarbon *trans*-chlordane compared to the PAH, BaP when exposed in laboratory-dosed sediments. Thus, differential bioavailability of a chemical may not depend as much on behavior as on the nature of the compound and its interactions with the sediment componets. As suggested above, differential sorption among sediment componets may be more important for determining bioavailability than other aspects such as feeding selectivity.

Another assay incorporating only the >20 μm size sediment particles will be completed in September, 1992. Accumulation of HCBP and BaP will be determined and assimilation efficiencies calculated as in the previous assays. Data obtained from this assay may explain the differences in accumulation seen in assays 2 and 3, and will further determine the selective feeding mechanism involved in *Diporeia* spp. The results of the above will dictate the direction for future efforts.

List of Publications Sponsored by the U. S. Air Force Office of Scientific Research - Postdoctoral Award:

Lydy, M. J., J. T. Oris, P. C. Baumann, and S. W. Fisher. 1992. Effects of sediment organic carbon content on the elimination rates of neutral lipophilic compounds in the midge (*Chironomus riparius*). Environ. Toxicol. Chem. 11(3):347-356.

Fisher, S. W., M. J. Lydy, J. Barger, and P. F. Landrum. 1992. Quantative structure activity relationships for predicting the toxicity of pesticides in aquatic systems with sediment. Environ. Toxicol. Chem. In press.

Lydy, M. J., W. L. Hayton, A. Staubus, J. T. Oris, and S. W. Fisher. 1992. Pharmacokinetics of pentachlorophenol and 5,5',6-trichlorobiphenyl to *Chironomus riparius*. Aquatic tox. In review.

Lydy, M. J., G. A. Harkey, J. Kukkonen. and P. F. Landrum, 1992. Assimilation of benzo(*a*)pyrene and 2,2',4,4',5,5'-hexachlorobiphenyl to *Diporeia* spp. In preparation.

Presentations:

Lydy, M. J. and P. F. Landrum. 1991. Assimilation efficiency for selected PAH and PCB congeners sorbed to sediment by *Diporeia* spp. Society of Environmental Toxicology and Chemistry (SETAC), Seattle, WA. November 1991.

Fisher, S. W., M. J. Lydy, and P. F. Landrum. 1991. Qsars for predicting the toxicity of cholinergic pesticides in aquatic systems with sediment. Society of Environmental Toxicology and Chemistry (SETAC), Seattle, WA. November 1991.

Lydy, M. J. 1992. Interstitial water vs. ingestion - Which represents the major route of uptake of sediment-sorbed contaminants? Invited seminar, Indiana University, Purdue University at Fort Wayne, Ft. Wayne, IN, March 1992.

Harkey, G. A. and P. F. Landrum. 1992. Evaluating the accumulation of hydrophobic compounds to whole sediment, porewater, and elutriates. Invited seminars, Clemson University, Pendleton, SC, May 1992, and Indiana Water Resources Association Symposium, Marshall, IN, May 1992.

Lydy, M. J. 1992. Overview of aquatic toxicology. Invited seminar, Indiana Water Resources Association Symposium, Marshall, IN, May 1992.

Lydy, M. J., G. A. Harkey, J. Kukkonen, and P. F. Landrum. 1992. The importance of ingestion in the bioaccumulation process. Society of Environmental Toxicology and Chemistry (SETAC), Cincinnati, OH, November 1992.

Harkey, G. A. and P. F. Landrum. 1992. Evaluating the bioavailability of *trans*-chlordane and benzo(*a*)pyrene in whole sediment, porewater, and elutriate exposures. Society of Environmental Toxicology and Chemistry (SETAC), Cincinnati, OH, November 1992.

Professional Personnel Associated with the Research:

1. Dr. Peter Landrum, Great Lakes Environmental Research Laboratory. Post-doctoral advisor.

2. Ms. Gail Harkey, Great Lakes Environmental Research Laboratory and Clemson University. Graduate student associate.

3. Dr. Jussi Kukkonen, Great Lakes Environmental Research Laboratory. Visiting scientist; technical assistant.

4. Dr. Susan Fisher, Ohio State University; Dr. Paul Baumann, U. S. Fish and Wildlife Service; Dr. William Hayton and Dr. Al Staubis, Ohio State University; and Dr. Jim Oris, Miami University. Coauthors of manuscripts.

Fiscal Report

(1) Personnel:

Total salary and fringe benefits to Gail Harkey as of 7/1/92	=	$13,092.05
Stipend to Dr. Michael Lydy	=	3,975.00
Total salary and fringe benefits available from 7/1/92 - 12/31/92 (to be expended by 12/31/92 or shortly thereafter)	=	15,857.95

(2) Expendible Supplies:

Total expendible supplies charged to this grant (through 8/31/92)	=	$4,789.10

(3) Permanent Supplies:

No permanent supplies were charged to this account.

(4) Travel and Other Expenses:

Travel and other expenses charged to this grant (through 7/1/92)	=	$397.69
Projected travel expenses to SETAC meeting, Cincinnati, OH, Nov. 1992	=	$500.00

(5) Indirect Costs:

University of Michigan overhead (8%) as of 7/1/92	=	$1,407.42
(6) Total Costs Charged as of 7/1/92	=	$23,661.26
(7) Projected Expenses, 7/1/92 to 12/31/92	=	$16,676.74
(8) Total amount of funding	=	$40,338.00